



The ANNIE Experiment

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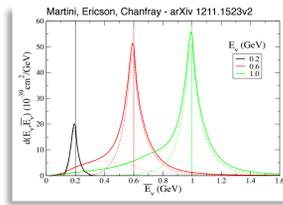
Accelerator Neutrino-Neutron Interaction Experiment

ANNIE is a water Cherenkov neutrino-neutron experiment in Fermilab's Booster neutrino beamline

GOAL is to measure the abundance of final state neutrons from neutrino-nucleus interactions in water, as a function of energy

ν -Nuclei Interactions?

To turn neutrino physics into a precision science we need to understand the complex multi-scale physics of neutrino-nucleus interactions

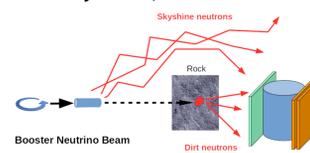


- Dominant source of systematics on future long baseline oscillation physics
- Source of uncertainty and controversy in short baseline anomalies

We need comprehensive and precise measurement for a variety of targets/ E_ν

Run I

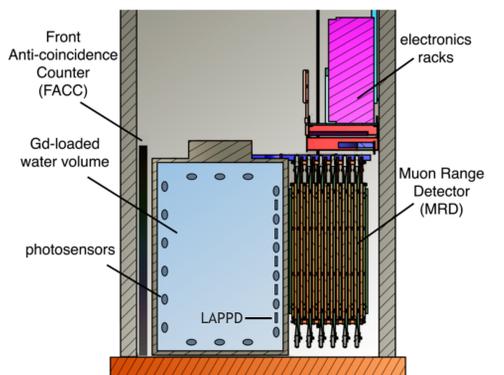
- Proof of concept
- Measure neutron background rates in the Hall : skyshine, dirt neutrons



Run II

- A key physics measurement in understanding the nature of neutrino-nucleus interactions
- Application of a new photodetector technology for detecting neutrinos

Run II Detector



ANNIE Installation

Tank and Inner Structure

- 10'x13' tank, with a white inner liner for light reflection and water containment
- Filled with roughly 26-tonnes of ultra-pure water
- Continuous nitrogen flow to kill biologics
- Water recirculation system (UC Davis)



Forward Veto and Muon Range Detector



- Veto consists of two layers of scintillator paddles (26 channels)
- First two layers of the MRD are in use (55 channels)
- Combined with the Veto, the MRD tags muons going through the detector



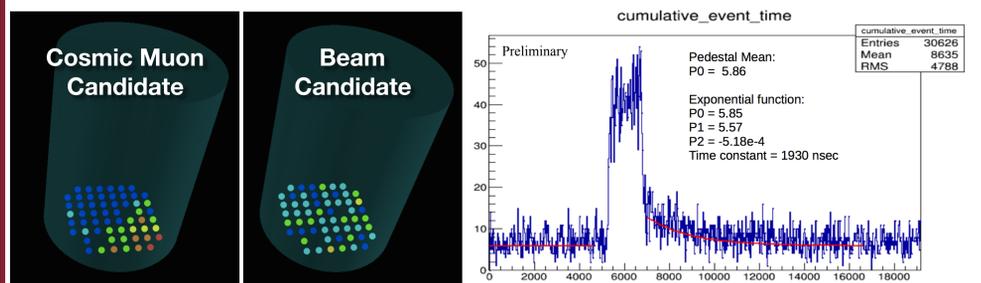
PMTs and Neutron Capture Vessel

- Sixty 8" Hamamatsu PMTs, recycled from SuperK and on loan from UC Irvine
- Neutron capture vessel (NCV) is a neutron-sensitive subvolume within the tank
- 50 x 50 cm acrylic vessel (built at UC Davis), filled with ~100 liters of Gd-doped liquid scintillator (EJ-335 liquid scintillator, from Eljen)
 - Pseudocumene-based (high light yield), 0.25% Gd-loading
- Using a winch system, the NCV can be moved in the vertical direction and along the beam direction → Allows for a measurement of the neutron rate at different locations within the tank



Run I Results

- Cosmic rays : distinguishable by high intensity, directional illumination
- Beam events : lower energy, uniform light yield
- Muon decay : identified as exponentially decaying event excess after beam peak



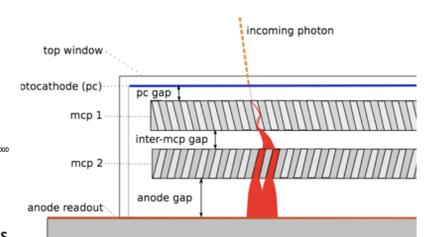
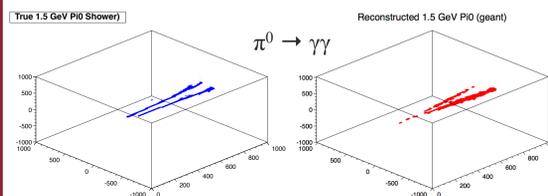
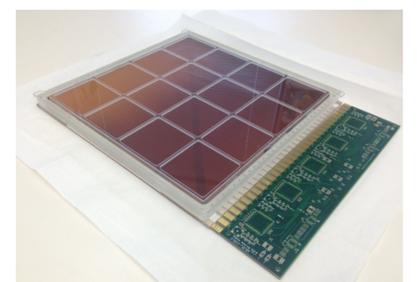
LAPPDs

Large Area Picosecond PhotoDetector

LAPPD's timing resolution is essential for neutrino vertex reconstruction

Promising new technology for detecting neutrinos

- Large, flat-panel, microchannel plate-based photosensors
- 50-100 picosec time resolutions and <1 cm spatial resolutions
- Based on new, potentially economical industrial processes with applications in particle physics, nuclear physics, X-ray science, and medical imaging
- LAPPD design includes a working readout system



- Tracks are reconstructed from the timing of the light arrival, LAPPDs help to discriminate between single and multi-track events
- ANNIE scale (3 m cubic) detector, assuming 100% LAPPD coverage

Summary

- ANNIE (Run II) seeks to measure the abundance of final state neutrons from neutrino interactions in water, as a function of energy
- ANNIE (Run I) is currently taking data and will run into 2017
- ANNIE has been funded by the DOE through the Intermediate Neutrino Program for an extension of Run I to demonstrate LAPPD readiness this year
- The Run II proposal plans on a realistic delivery schedule of 20 LAPPDs in 3 years by Incom, Inc., additional conventional PMTs and waveform sampling electronics are also proposed
- ANNIE's planned 5 year physics program will play a role in a variety of physics topics